

SPECIFICATIONS FOR LASER MACHINING CENTER

SECTION 1.0 GENERAL REQUIREMENTS

1.1 Scope.

The Naval Research Laboratory (NRL), Washington, D.C. has a requirement for a turnkey laser machining center. This system will be used for precise “machining” (i.e., cutting, drilling, engraving) and heat-activated bonding operations on a wide variety of materials. The laser machining center must be suitable for the purposes of research and development of new advanced material systems and must have wide-ranging capabilities for user control over the laser processing parameters. The laser machining center will be placed in a multiple user facility and must provide ease of operation (suitable for use by multiple individuals with no prior experience in laser machining), and safety to those in the facility. The laser machining center must meet or exceed the following minimum specifications:

1.2 Installation Site.

The contractor shall install the laser machining center in Bldg. 28, Naval Research Laboratory, Washington DC 20375, at the location specified by the government Technical Manager (TM). NRL will be responsible for providing the necessary facilities/utilities at that location for the proper installation of the laser machining center. The contractor shall provide a pre-installation guide with its proposal submitted in response to the solicitation. The pre-installation guide shall indicate, in detail, all of the site requirements including, but not limited to: environment (e.g. temperature, vibration, air flow, etc.); utility hook-ups (e.g. electrical, air, water, vacuum, etc.); fume/particle exhaust venting; required space (e.g., doorway passage, floor, operating, maintenance access, etc.); procedures for receiving the equipment and placing it in its laboratory location; and communication hook-ups (e.g. Ethernet). The laser machining center shall be ready for immediate use following installation by the contractor.

1.3 Primary System Components.

The system shall contain at least the following major components:

- 1.3.1 Sealed CO₂ laser with pulse power control.
- 1.3.2 Focusing optics system on a planar horizontal gantry (flying optics).
- 1.3.3 Computer automated system for set-up, operation, and process control.
- 1.3.4 Vertically adjustable machining bed with vacuum hold-down for work-piece support.
- 1.3.5 Laser Class I safety enclosure with safety interlocks, fume/particle exhaust, front/rear/top machining bed access.
- 1.3.6 Gas-assist system for creating and maintaining specific elemental gas environment conditions at the site of laser machining on the work-piece.

- 1.3.7 MS Windows compatible computer with appropriate laser machining center process control software with CD back-ups and printed technical documentation.
- 1.3.8 Visible laser guide for locating the work-piece materials relative to the laser-beam focus point within the machining area.

SECTION 2.0 SYSTEM REQUIREMENTS

2.1 Laser.

The laser machining center must be equipped with a sealed CO₂ laser with pulse power control capability. The laser must be capable of providing an average output power of 500W and a peak output power of 1500W, both measured at 10.5 microns wavelength. Continuous or discrete control of the laser-beam output power, from low to maximum, is required for engraving/etching and heat-activated bonding processing where precise control of the amount of heat-input over well-defined, focused regions of the work-piece is needed. The laser system must be capable of operating a minimum of 15000 hours before the laser has to be removed from the machine for maintenance/rebuilding. The contractor shall provide all auxiliary equipment (e.g., chiller) necessary for operation of the laser.

2.2 Machining Capabilities: Materials.

The laser machining center must be capable of machining (cutting, drilling, and engraving) operations on polymers, composites, metals, natural materials, and ceramics in a variety of forms including sheet, foil, solid, and foam. Specific materials include, but are not limited to:

- 2.2.1 Polymers: PP, PE, Kevlar, LCP, ABS, elastomers, acrylic, acetates, nylon, vinyl, Teflon, styrene, polycarbonate, etc.
- 2.2.2 Fiber-reinforced (chopped, continuous, woven, and non-woven) polymer composites in the B-staged (prepreg) and fully-cured state. The fibers may include: glass, carbon, graphite, aramid, metal, etc. and the matrix materials may be a thermosetting polymer like: epoxy, cyanate ester, etc. or thermoplastic like: PPS, LCP, etc.
- 2.2.3 Metals: iron/steel alloys (mild, stainless, high-alloy, tool, etc.), titanium alloys, aluminum alloys, brass/bronze alloys, etc.
- 2.2.4 Natural Materials: paper, card-board, wood, woven clothes, leather, rubber, etc.
- 2.2.5 Ceramics: ceramic-polymer tapes (~50-50%), PZT ceramics, glass, etc.

2.3 Machining Capabilities: Motion Control and Performance.

- 2.3.1 The laser-beam focus spot diameter shall be controllable. The laser/optics must be capable of focusing to a spot diameter of 0.005 inches or smaller on the work-piece.
- 2.3.2 The traverse speed of the focused laser-beam spot on the work-piece shall be controllable. The machine must be capable of 1000 inch/min or greater machining speed.

2.3.3 The motion control accuracy of the focused laser-beam spot must be plus or minus 0.001 inches per foot or better. The motion control repeatability of the focused laser-beam must be plus or minus 0.0005 inches per foot or better.

2.3.4 The machine must be capable of a minimum of 12 inches of continuous vertical work-piece height adjustment within the machining area. The vertical height setting and adjustments shall be through electrical switch settings or through computer control.

2.4 Optics.

Flying optics with automatic laser-beam focusing to account for work-piece thickness are required. In addition, the laser-beam focus spot diameter on the work-piece shall be “user” controllable through electrical switch settings, as a fixed parameter during processing set-up, or through active control by the computer during the machining/heating process. Hardware and/or software features must be provided to protect the optics system from damage by cutting fumes, flames, particles, etc. and/or from collision with the work-piece during set-up or operation.

2.5 Housing.

The housing must provide a sealed laser workspace enclosure with Class I laser safety rating and safety interlocks. The laser machining center must operate, including work-piece loading into the machine, in an approximate 15 foot by 10 foot space. Multiple access “doors” (front, rear, top) to the machining bed shall be provided for ease in inserting and removing bulky or unwieldy material forms and material work-piece “carriage-frames” or “pallets.” The machine must incorporate a fume/particle exhaust system that can be vented outside of the laboratory work area. The contractor shall provide all auxiliary exhaust equipment. Particle filtering equipment and work-piece handling equipment are option items as noted below.

2.6 Machining Bed.

The machining bed must be greater than or equal to 4 feet but less than or equal to 8 feet in each of the horizontal dimensions. The machining bed must use vacuum suction to keep the work-piece from moving during processing. The contractor shall provide all necessary equipment for creating and maintaining vacuum on the machining bed for work-piece hold-down.

2.7 Gas Assist System.

The contractor shall provide a gas-assist system for creating and maintaining specific elemental gas environment conditions at the site of laser machining on the work-piece. Such a system must consist of flying nozzle(s) that can supply a flow/pressure regulated gas stream directly to the point of laser machining. This gas-assist system must support the use of inert gases, oxygen, nitrogen, and air for specific cutting processes. External supply port(s) and automated control of the gas flow rate and pressure must be provided.

Hardware and/or software features must be provided to protect the gas-assist system from damage by collision with the work-piece during set-up or operation..

2.8 Control of the laser machining center.

The laser machining center must have both manual and computer-automated control capabilities. The computer used for control shall be MS Windows compatible, and must have a flat panel color monitor of least 17 inches diagonal. The contractor shall provide all necessary software for set-up, operation, and process control of the laser machining center along with copies of the software on CD(s) and hardcopy manuals and documentation as is customarily supplied with this software. The computer must be capable of being located remotely to the laser machining center with connection(s) to the laser machining center, via cabling, and to the internet through Ethernet porting. The laser machining center software shall be capable of accepting a variety of drawing formats including, but not limited to: *.DWG, *.DXF, and Gerber (G-code).

SECTION 3.0 ACCEPTANCE CRITERIA

The contractor shall demonstrate the machine's capability/functions at time of installation. More specifically, the contractor shall demonstrate use of the laser machining center for cutting the following NRL-DC supplied materials: polypropylene sheet ($\leq 1/4$ inch thick); carbon and Kevlar fiber bundle tows; carbon-epoxy and glass-epoxy prepreg layers (≤ 0.040 inch thick); cured carbon-epoxy sheet ($< 1/4$ inch thick); stainless steel sheet ($\leq 1/16$ inch thick), aluminum sheet ($\leq 1/16$ inch thick), paper, solid wood sheet (≤ 1 inch thick), and plywood sheet ($\leq 3/4$ inch thick). The laser-beam pattern used in the cutting demonstrations shall be selected to verify the accuracy, repeatability, and focusing capabilities of the machine. The contractor shall also demonstrate use of the laser machining center for engraving/etching the following NRL-DC supplied materials: carbon steel, stainless steel, and wood. Similarly, the laser-beam pattern used in the engraving demonstration shall be selected to verify the accuracy, repeatability, and focusing capabilities of the machine.

SECTION 4.0 INSTALLATION AND TRAINING

The contractor shall install the system at NRL-DC. The contractor shall provide at least 2 days of training (functionality, operation, and trouble-shooting) for a minimum of eight NRL representatives at NRL-DC. The training will be conducted over two sessions. Each session shall last at least one day with four or more NRL representatives per session. The topics covered in each session shall focus on training the NRL representatives in the laser machining center's functional capabilities and operational procedures. The first session will commence within 30 days after the system is installed and up and running at NRL. The second (repeat) session will be scheduled at a time mutually agreed upon by NRL and the contractor up to one year after the machine is installed and running.

SECTION 5.0 WARRANTY

The contractor shall offer the Government at least the same warranty terms, including offers of extended warranties, offered to the general public in customary commercial

practice. These warranty terms must be included in the system price. The period of the warranty shall begin upon acceptance.

SECTION 6.0 DOCUMENTATION

a. A full set of all written documentation customarily provided to the public with a commercial item shall be provided. This shall include users manual(s) or equivalent as well as copies of any software, and any manuals for the software included with the system, if customarily provided. This documentation must be received at NRL with the system hardware, unless other arrangements are agreed to by the authorized Government representative. This documentation shall also include all documentation, drawings and schematics for full site preparation, operation, troubleshooting, servicing and repair of the system and its components.

SECTION 7.0 OPTIONAL ITEMS

The following items are option items:

7.1 Option I – Materials Alignment/Registration System

The contractor shall provide hardware/software for use in performing and/or automating precision alignment, and for locating, and registering work-piece materials relative to the laser-beam focus point on the machining bed.

7.2 Option II – Localized Work-Piece Heating Capability

The laser machining center must perform localized heating of work-piece materials without excessive heating or melting that “damages” the material. This feature is desired for use in creating localized bonding between multiple stacked material layers through thermoplastic polymer welding or heat-activated adhesive bonding. Laser machining center features that may facilitate this capability include, but are not limited to: active or passive control of the laser-beam power and pulse settings from minimum to maximum; active or passive control of the laser-beam focus diameter from the minimum diameter up to 0.125 inches diameter or more, active control of laser-beam traverse speed. Active control is computer automated control of settings that can be varied during laser processing. Passive control is manual or computer control of settings that remain fixed during laser processing.

7.3 Option III -- Dust Filtering System

The contractor shall provide equipment for filtering and collecting small dust particles generated during the machining process.

7.4 Option IV – Work-Piece Materials Handling Equipment

The contractor shall provide equipment for mounting, handling, and loading work-piece materials into the laser machining center. This might include a machining bed that shall be capable of accepting and working with the work-piece “carriage-frames” or “pallets” that

can be inserted and/or removed from the front or rear of the machine, and lifts or carts for transporting the “carriage-frames” or “pallets” from the work-piece mounting area to the laser machining center.

7.5 Option V – Software Error Checking Capability

The contractor shall provide software for checking the imported drawing files for errors prior to laser machining center operation.